

Portland Harbor Sediment Toxicity Assessment — Uncertainty Analysis



John Toll, PhD

SETAC North America 46th Annual Meeting
Session 2.09.T—Large River Monitoring:
Programs, Design, Methods and Interpretations

Thursday, November 20, 2025





Portland Harbor Baseline Ecological Risk Assessment



- Great example of ecological risk assessment for large river sites
- One small piece: analyzing uncertainty in sediment toxicity test findings

Search for Portland Harbor Remedial AR File Baseline Ecological Risk Assessment

Date	Title	Doc ID	Author	Addressee
<input type="text" value="Search Date"/>	<input type="text" value="Search Title"/>	<input type="text" value="Search Doc ID"/>	<input type="text" value="Search Author"/>	<input type="text" value="Search Addressee"/>
06/08/2016	Portland Harbor Remedial AR File Baseline Ecological Risk Assessment Index (1 pp, 10.03 KB)	790001		
12/16/2013	Final Remedial Investigation Report Appendix G Baseline Ecological Risk Assessment Final, Volume I. (870 pp, 404.3 MB)	1432515	(Windward Environmental, LLC)	(EPA); (Lower Willamette Group (LWG))
12/16/2013	Final Remedial Investigation Report Appendix G Baseline Ecological Risk Assessment Final, Volume II Attachments. (1096 pp, 83.11 MB)	1432516	(Windward Environmental, LLC)	(EPA); (Lower Willamette Group (LWG))
Date	Title	Doc ID	Author	Addressee

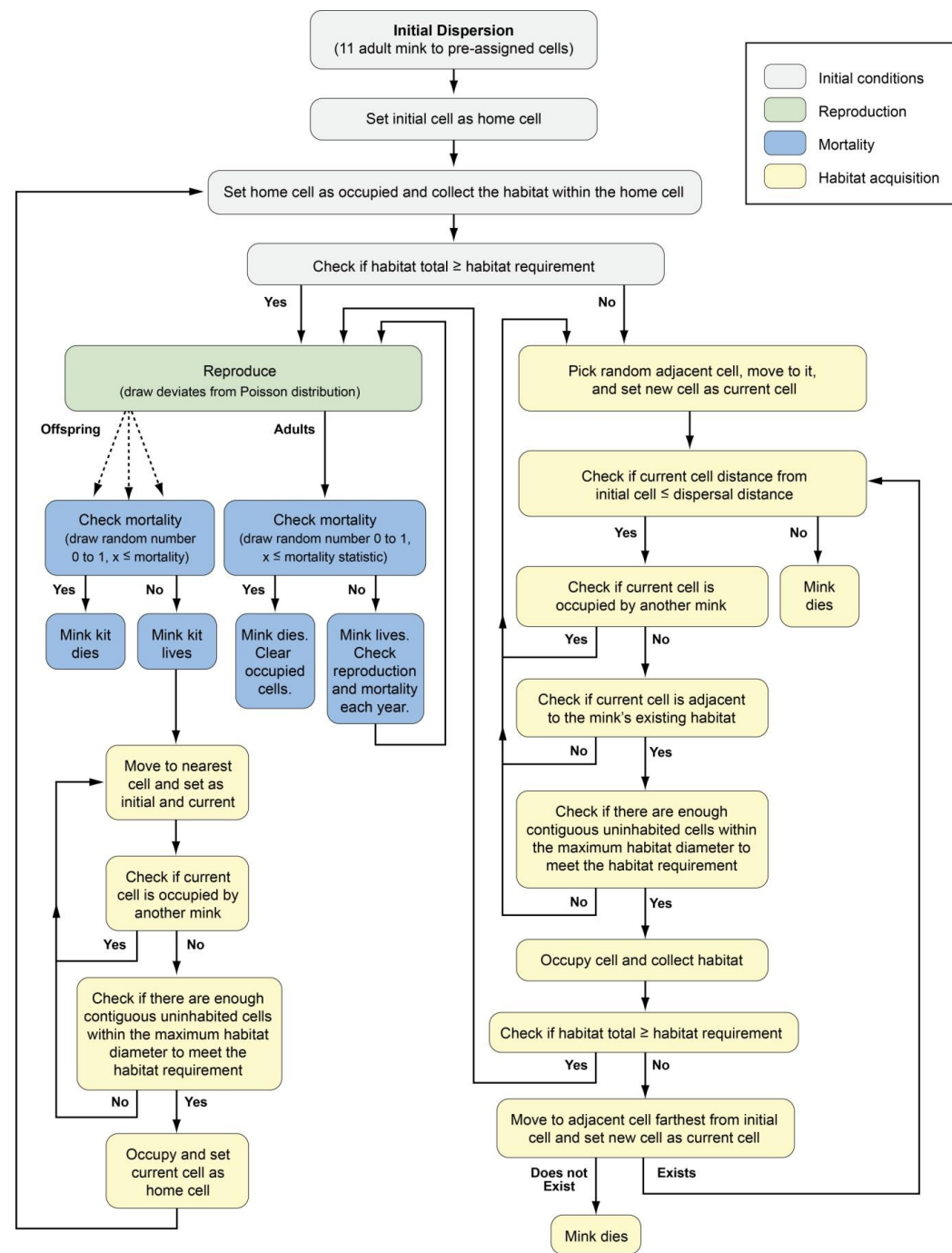
<https://cumulis.epa.gov/supercpad/cursites/cscdocument.cfm?id=1002155&doc=Y&colid=34384>

Portland Harbor Baseline Ecological Risk Assessment



Also of interest

Luxon, Toll and Hanson. 2013. Assessing Effects of PCB Exposure on American Mink (*Mustela vison*) Abundance in Portland Harbor. IEAM 10(1):20-68.



Overview of the process



Iterative approach to ecological risk assessment (EPA, 1997)

1. Screening-level problem formulation and ecological effects evaluation
2. Screening-level preliminary exposure estimate and risk calculation
3. Baseline risk assessment problem formulation
4. Study design and data quality objectives
5. Field verification of sampling design
6. Site investigation and analysis of exposure and effects
7. Risk characterization
8. Risk management

The screenshot shows the EPA website header with the logo and search bar. Below the header is a navigation bar with links for Environmental Topics, Laws & Regulations, Report a Violation, and About EPA. The main content area features a breadcrumb trail: Home / Risk Assessment / Superfund Risk Assessment / Superfund Ecological Risk Topics. On the left, a sidebar lists 'Risk Assessment' topics: About Risk Assessment, Risk Recent Additions, Human Health Risk Assessment, Ecological Risk Assessment, Risk Assessment Guidance, and Risk Tools and Databases. The main content area displays the title 'Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments - Interim Final' and a brief description: 'This document provides guidance to site managers and Remedial Project Managers who are legally responsible for the management of a site on how to design and conduct technically defensible ecological risk assessments for the Superfund program.'

<https://semspub.epa.gov/work/HQ/157941.pdf>

Overview of the process



- No guidance document can describe procedures to fully evaluate ecological risks at sites as complex as Portland Harbor
- Numerous site-specific procedures, methodologies, memoranda, and intermediate data reports and analyses have been developed and presented in documents prepared by the Lower Willamette Group, in collaboration with and under the oversight of EPA and federal, state, and tribal partners
- My goals for today:
 - Pique your interest
 - Make you aware of available resources
 - Let you know I'm eager to help



PORTLAND HARBOR RI/FS
FINAL REMEDIAL INVESTIGATION REPORT

APPENDIX G
BASELINE ECOLOGICAL RISK ASSESSMENT

FINAL

Volume I

December 16, 2013

Prepared for
The Lower Willamette Group and
United States Environmental Protection Agency

Prepared by
Windward Environmental LLC

<https://cumulis.epa.gov/supercpad/cursites/cscdocument.cfm?id=1002155&doc=Y&colid=34384>

The environmental risk assessor's job



Rigorously characterize nature and extent of environmental risk associated with a site or situation



Advance state of the science



Uncover facts that are difficult to discover



Build trust

Invertebrate sediment toxicity assessment



- Reference envelope approach (MacDonald and Landrum 2008) provided as BERA Attachment 6, Part B

An Evaluation of the Approach for Assessing Risks to the Benthic Invertebrate Community at the Portland Harbor Superfund Site

Preliminary Draft

Prepared for:

**U.S. Environmental Protection Agency
Oregon Operations Office
805 SW Broadway, Suite 500
Portland, Oregon 97205**

and

**Parametrix, Inc.
33972 Texas Street SW
Albany, Oregon 97321**

Prepared - *September, 2008* - by:

**D.D. MacDonald
MacDonald Environmental Sciences Ltd.
#24 - 4800 Island Highway North
Nanaimo, British Columbia V9T 1W6**

**P.F. Landrum
Landrum and Associates
6829 Earhart Road
Ann Arbor, Michigan 48105**

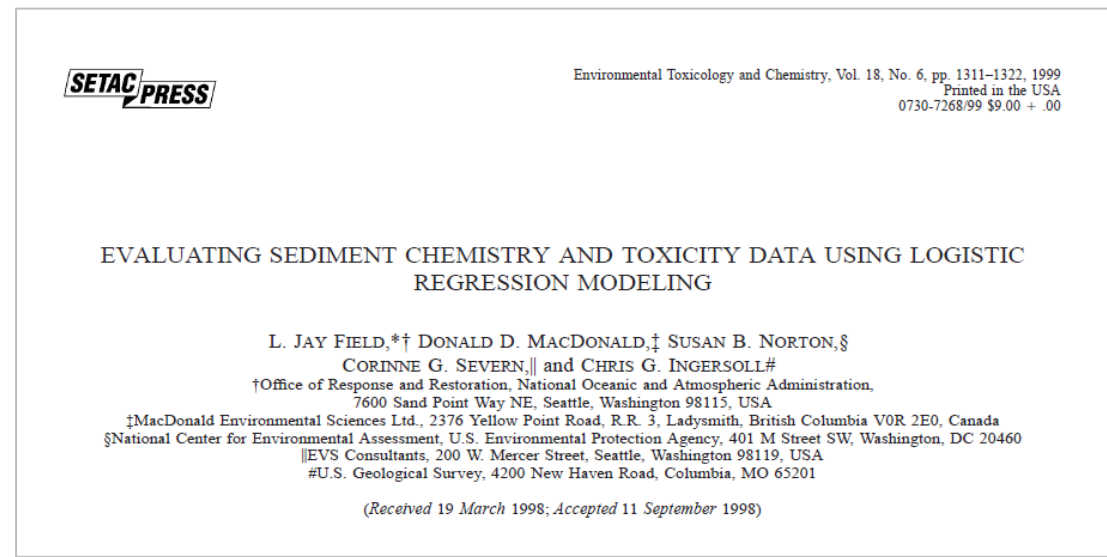


Invertebrate sediment toxicity assessment



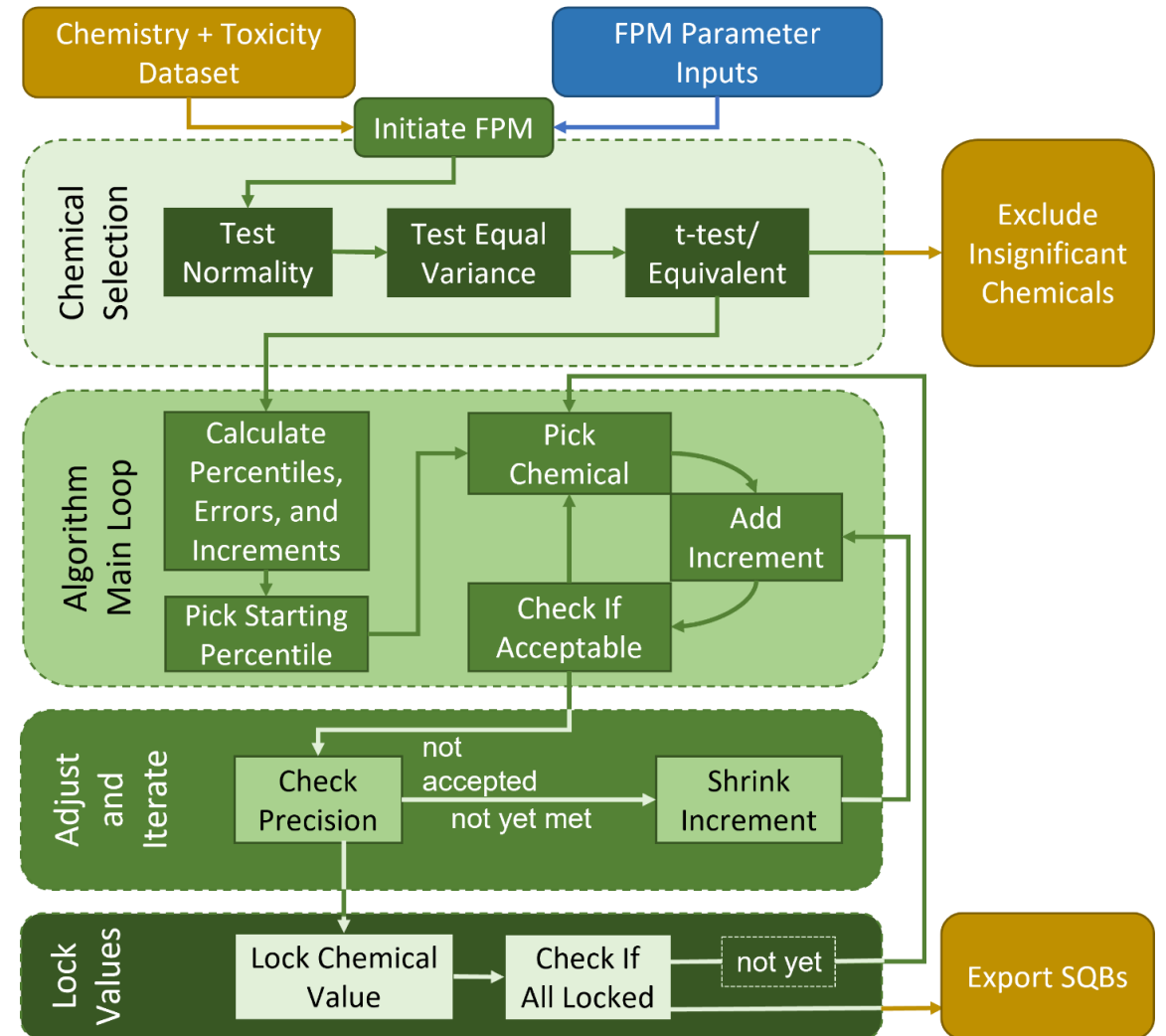
- Two predictive benthic toxicity models selected after extensive consultation with EPA and others
 - Floating percentile model (FPM) (Regional Sediment Evaluation Team 2009)*
 - Logistic regression model (LRM) (Field et al., 1999)
- FPM and LRM used to develop site-specific sediment quality values (SQVs)
 - Identified chemicals most associated with sediment toxicity
 - For each chemical, developed a site-specific SQV to predict sediment toxicity to benthic organisms with an estimated degree of reliability

**The RSET Sediment Evaluation Framework was updated in 2016 and published in May 2018*
(<https://usace.contentdm.oclc.org/digital/collection/p16021coll11/id/684/>)



Floating percentile model

- Original software a “black box”
 - Limited user control
 - Locked access to the tool’s underlying code
 - Not readily available
- Our package implements the FPM in R
 - Expanded user controls
 - Open code
 - Readily available for public use and evaluation



<https://www.barr.com/floating-percentile-model/>

Invertebrate sediment toxicity assessment



- FPM and LRM performance assessed with reliability framework (EPA, 2010) in September 2010 letter to Lower Willamette Group (from E. Blischke and C. Humphrey to R. Wyatt) about Portland Harbor Superfund site: EPA comments on benthic risk evaluation



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
OREGON OPERATIONS OFFICE
805 SW Broadway, Suite 500
Portland, Oregon 97205

September 27, 2010

Mr. Bob Wyatt
Northwest Natural & Co-Chairman, Lower Willamette Group
220 Northwest Second Avenue
Portland, OR 97209

Re: Portland Harbor Superfund Site; Administrative Order on Consent for Remedial Investigation and Feasibility Study; Docket No. CERCLA-10-2001-0240
EPA Comments on Benthic Risk Evaluation

The data and how they were used

|||||||



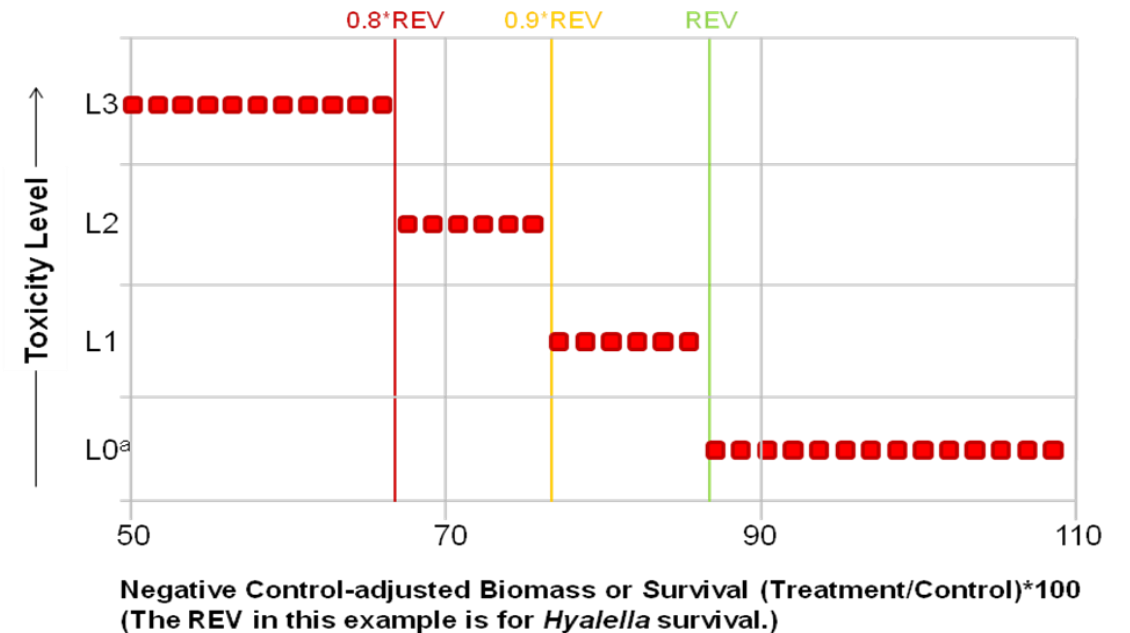
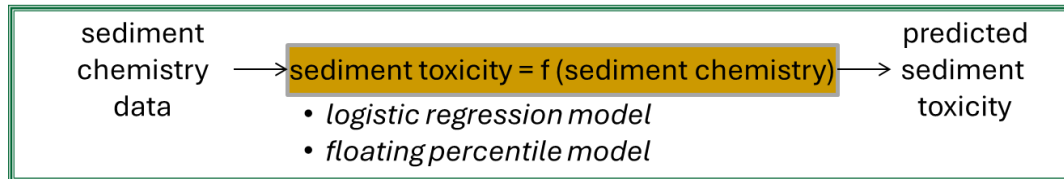
Test and endpoint	REV (%)	0.90*REV	0.80*REV
<i>C. dilutus</i> survival	93.9	84.5	75.1
<i>C. dilutus</i> biomass	91.0	81.9	72.8
<i>H. azteca</i> survival	88.1	79.3	70.5
<i>H. azteca</i> biomass	73.6	66.2	58.9

The data and how they were used

|||||||

1,920 surface sediment chemistry samples
-293 sediment toxicity test samples

1,627 toxicity predicted from chemistry

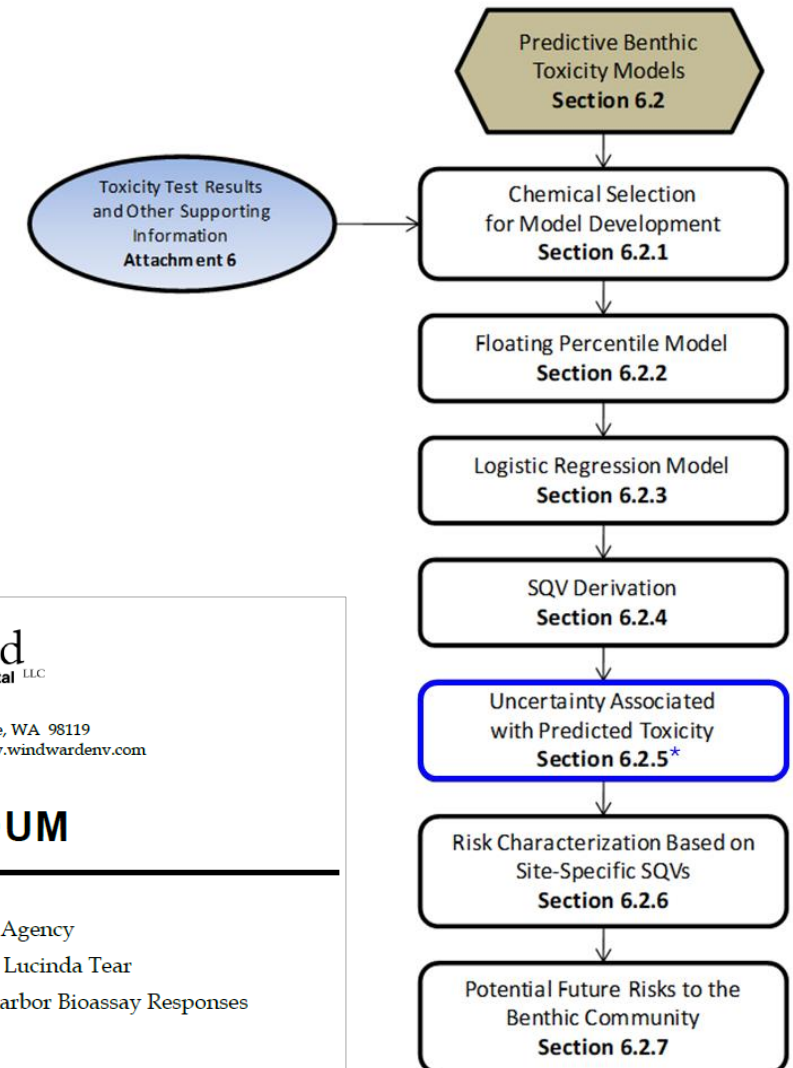


Uncertainty analysis*



- Calculates probability that each bioassay sample was assigned to the correct toxicity category
- Likelihood calculation quantified the probability that the sample's true mean response fell between the toxicity thresholds indicated by the sample mean
- Accounts for:
 - Variance in bioassay replicates
 - Uncertainty in magnitude of mean control response

*Final Remedial Investigation Report, Appendix G (BERA), Attachment 6 (Toxicity Test Results and Interpretation), Part C (Uncertainty Analysis) (pp. 119-126)



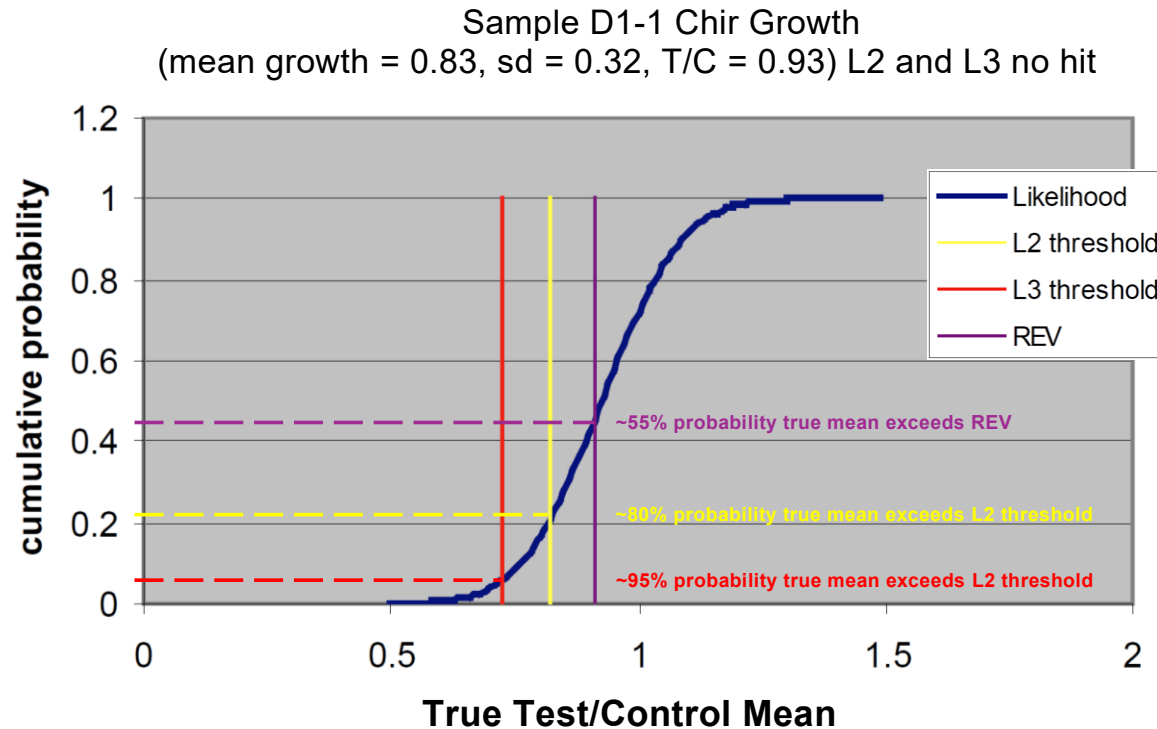
200 West Mercer St. • Suite 401 • Seattle, WA 98119
Phone: 206.378.1364 • Fax: 206.217.0089 • www.windwardenv.com

MEMORANDUM

To: Eric Blischke, US Environmental Protection Agency
From: John Toll, Lorraine Read, Nancy Musgrove, Lucinda Tear
Subject: Quantification of Uncertainty in Portland Harbor Bioassay Responses
Date: November 30, 2010

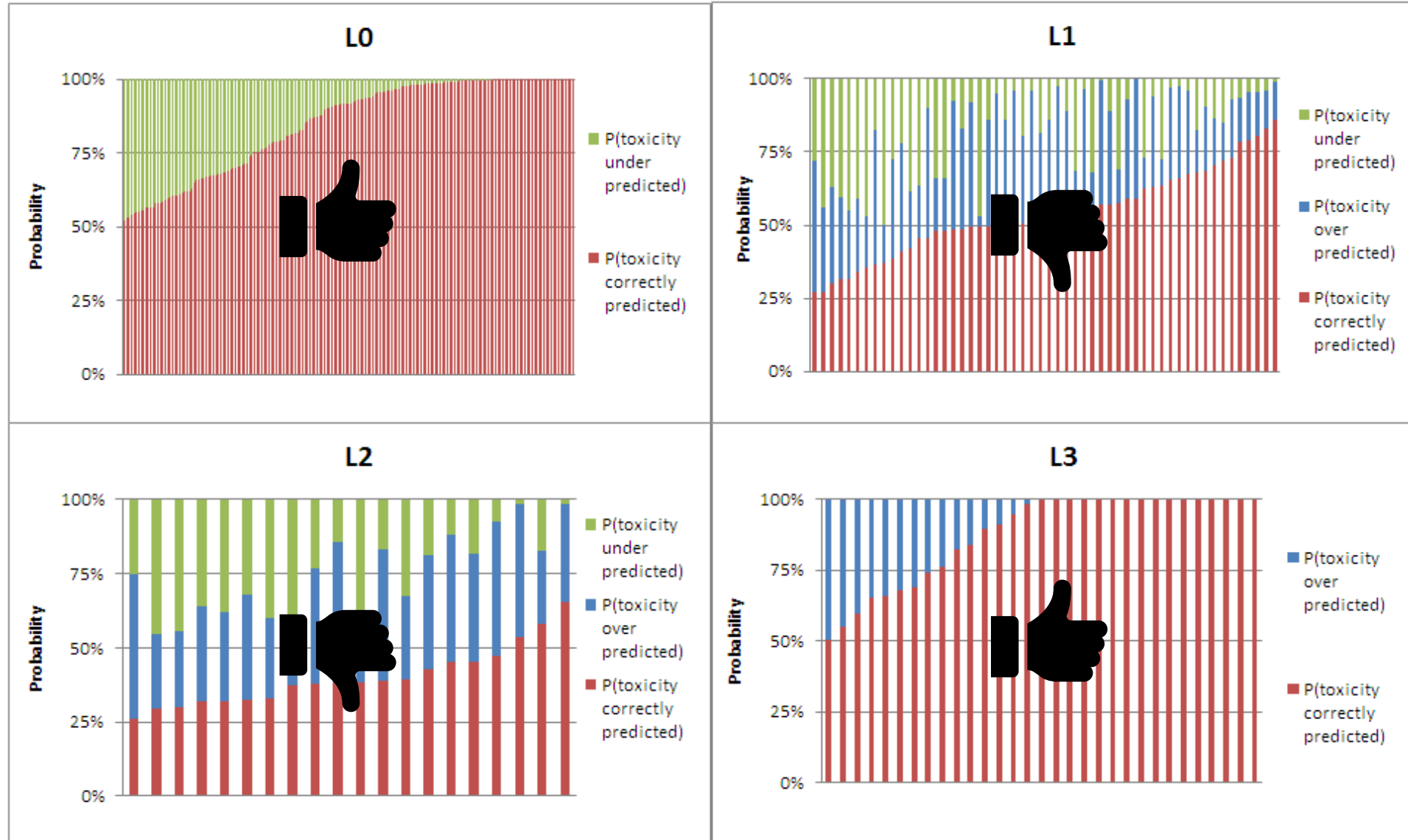
Cumulative probability distribution on true mean response for particular sample and endpoint (D1-1, *Chironomus* growth)

|||||||



$$-\ln L(\mu | X, s^2) = \sum_{i=1}^8 \ln(s\sqrt{2\pi}) + \frac{(X_i - \mu)^2}{2s^2}$$

1. Estimate sample variance s^2 for eight replicates
2. Estimate the negative log-likelihood for each possible value of μ
3. Convert negative log-likelihoods to likelihoods (multiply by -1 and exponentiate)
4. Divide individual likelihoods by sum of all likelihoods to convert likelihood values to a probability distribution
5. Treatment of uncertainty due to variance in control response: see Attachment 6, Part C, pp. 121–122

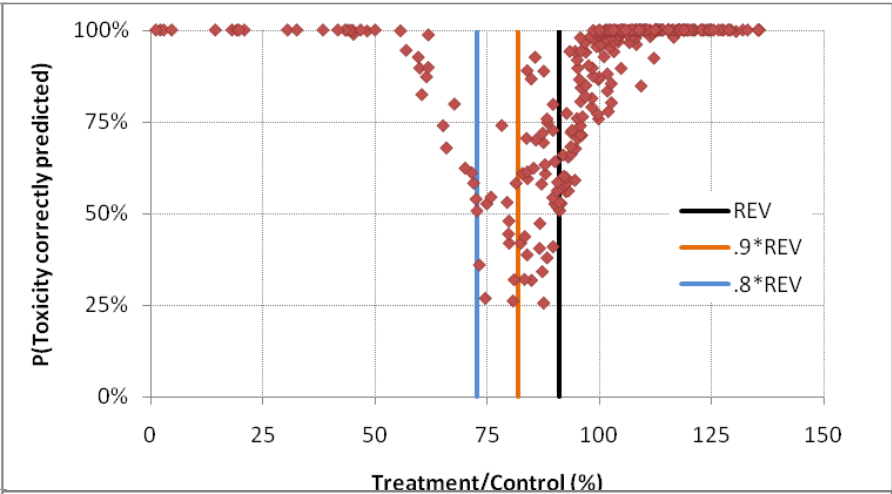
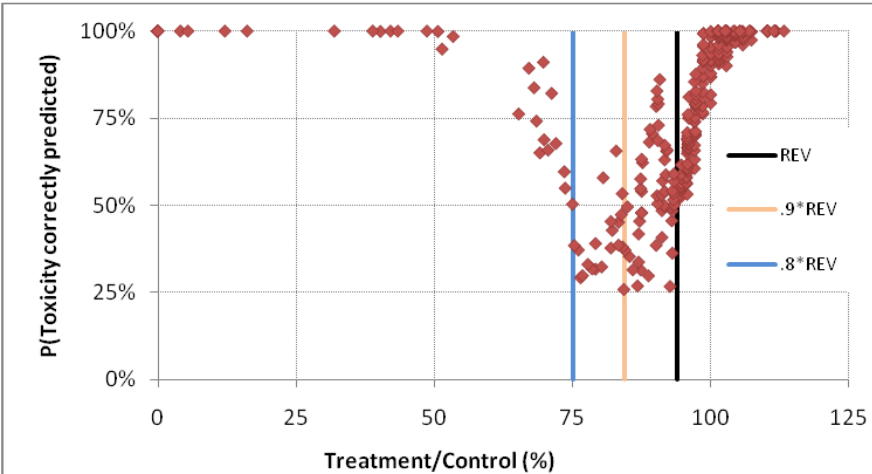


Stacked bar graphs of probabilities that toxicity is **correctly predicted**, **under-predicted**, or **over-predicted** based on Bayesian posterior probabilities. Each bar represents a bioassay station.

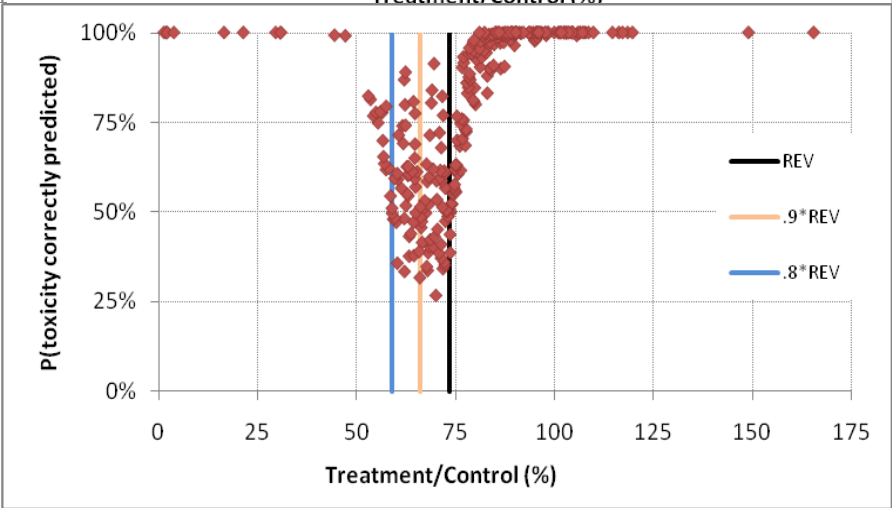
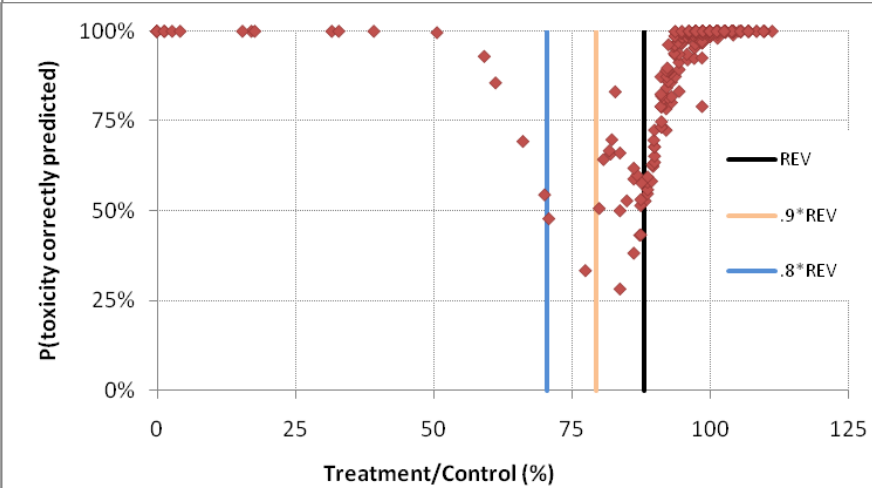
Probability of correctly predicting bioassay hit classification



Chironomus



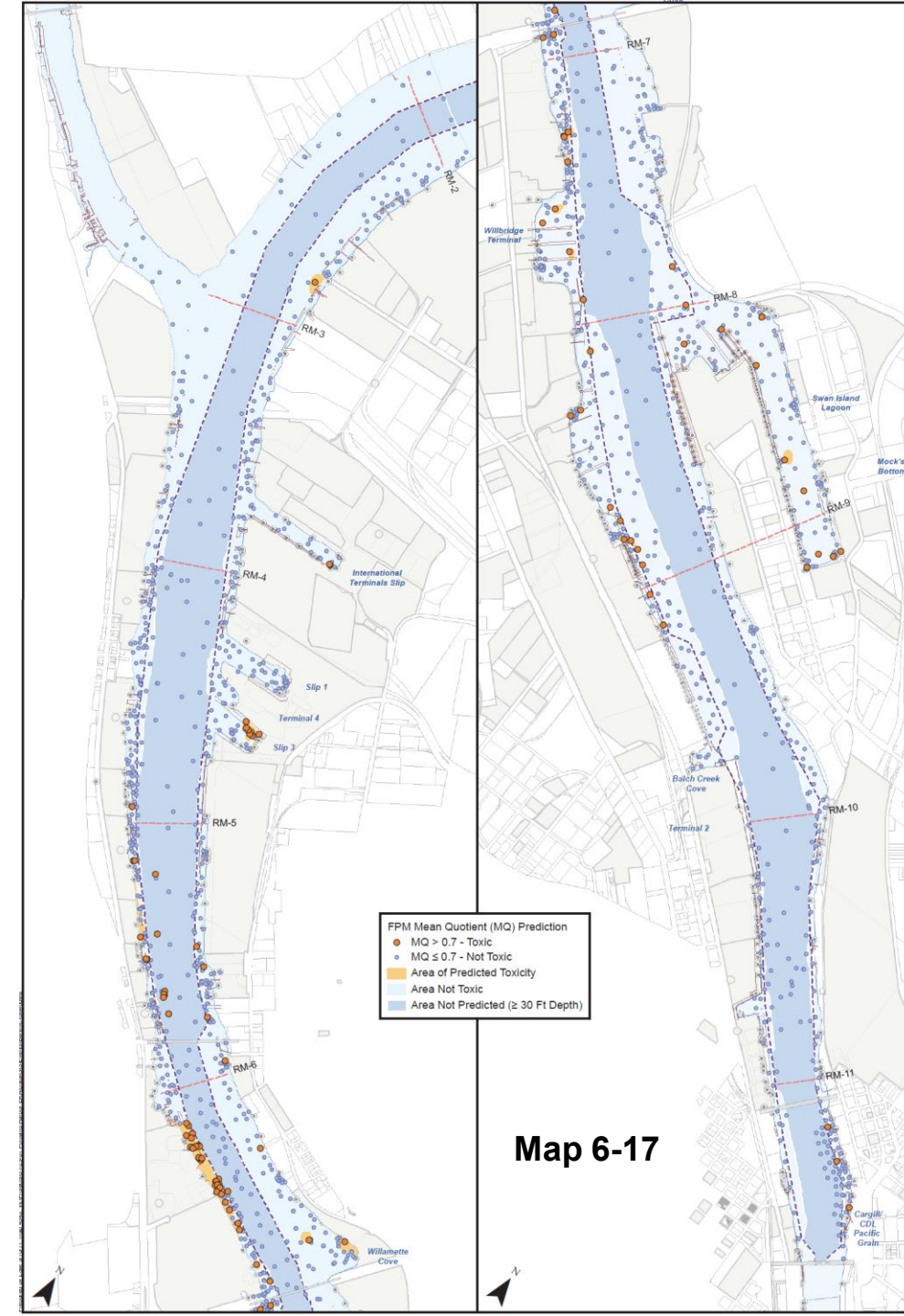
Hyalella



Summary of findings



- Understanding reliability of bioassay hit classifications influenced risk characterization methods and findings
- Multiple lines of evidence needed to support potentially unacceptable benthic risk conclusions based on L2 hits
- Potentially unacceptable benthic risks:
 - Highly associated with shoreline areas, slips, and areas of elevated sediment chemical concentrations
 - Represent appx. 7% of total study area



Map 6-17

Conclusion



- Portland Harbor BERA: large river investigation involving at least three of the four elements of the environmental risk assessor's job
 - Advanced state of the science
 - Advanced scientific rigor of characterizing nature and extent of environmental risk associated with a site or situation
 - Uncovered facts that were difficult to discover
 - Provided trial by fire for building trust and integrity
- There's a fifth element of the environmental risk assessor's job: translating risk findings into risk management decisions
 - We built the tools to assess reliability, but we didn't do enough to translate reliability analysis into simple cleanup metrics



Thank you



John Toll
jtoll@barr.com
206-913-3292